Operations and Engineering Division

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Organization and Mission

The Operations and Engineering Division (OED) has three sections: Operations, which is led by Richard Heese; Electrical Systems, led by Richard Biscardi; and Mechanical Engineering, led by Ed Haas. To serve the NSLS user community, our mission falls into three main areas:

- Operating the NSLS 24 hours a day, seven days a week, and, on average, 44 weeks a year
- Designing, fabricating, and maintaining the NSLS accelerators, infrastructure, and instruments, including upgrades, modifications, and proposal development
- Providing engineering and technical support for other NSLS divisions and the NSLS user community

The OED staff includes one scientist, 21 engineers, and 57 technicians, making it the largest of the NSLS divisions. In addition to its own staff, the division coordinates the activities of seven skilled tradesmen from Brookhaven Lab. The breadth of our mission is such that we need to draw on the capabilities of the other NSLS divisions for support and, in turn, provide specialized support for their activities.

2004 Activities

Maintenance and upgrade activities continue to be important factors in achieving high performance for the NSLS, a facility that is now entering its third decade of operations. For fiscal year 2004, overall reliability was above 90% for the x-ray ring and 99% for the VUV ring. An overview of machine performance is provided in this report's "Facility Facts and Figures" section. The facility continued to operate well throughout most of the year, with a few rough patches in April/May and July/August on the x-ray ring, which accounted for much of the year's downtime.

On April 21, with the May shutdown already set and fully scheduled, the x-ray ring injection septum vacuum chamber began to fail. It quickly became evident that the most complex vacuum chamber on the x-ray ring would need to be replaced as part of the shutdown. Fortunately, the last time the septum was replaced, in 1987, a spare was built that was available for this emergency repair (see photos on next page). Nonetheless, the installation is extremely difficult because the chamber is deeply buried in shielding and is captured by two of the large quadrupole magnets. As the scope of the task became clear, we advised the user community to expect *at least* a week delay in operations. Through careful planning and execution, as well as some very long hours, the actual installation only took four days longer than the originally scheduled shutdown. An additional four days went into conditioning the machine, which was also not part of the original plan.

Routine operations were established on June 1, which was, overall, just eight days later than planned in January when the schedule was released. Without the hard work and dedication of the staff, as well as the existence of the spare chamber, this problem could well have stretched into the summer and beyond. The whole activity emphasizes the importance of preparing for surprises, no matter how improbable they seem.

The injection septum chamber replacement overshadowed a significant body of other shutdown work. The power distribution maintenance on May 8 revealed problems in each of the three substations, which were resolved. None of these issues would have resulted in unsafe conditions, but they could have led to failures that would have caused substantial operations downtime.

No less significant were several major activities by the Utilities Group, aimed at improving the reliability of the NSLS cooling systems. One involved the addition of a third pump to act as a rotating spare for the low-pressure copper system that provides cooling for the machine power systems. Cleaning the high-pressure copper system heat exchangers was also required to bring the efficiency of that system back to specification.

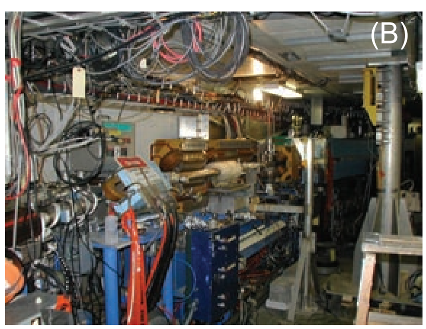
Since 2003, when a failure on the site chilled-water system dislodged debris from the distribution piping, we have been experiencing significant difficulty keeping these systems clear and fully functional. This fine silt-like material has been migrating to the low point of the system (the NSLS) ever since, clogging equipment strainers (see photo below), and fouling the heat exchangers for the machines. To head off continuing fouling, full-flow strainers were installed on the 12" lines from the site central chilled-water supply to the machine cooling equipment.

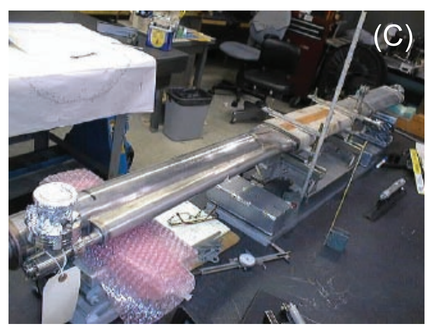
Although the unanticipated replacement of the x-ray injection ceramic in May was the single largest contributor of downtime for the year, we also experienced a swarm of small system failures from late July into August that accrued more than 45 hours of downtime, almost twice the average for a whole month. These two types of failures illustrate several important points.

From the user's perspective, the summer episode of unrelated equipment failures was more disruptive than the single large failure in May. In the case of the injection ceramic, we knew the magnitude of the problem and were able to provide the user community with advance notice. The series of problems we encountered this summer resulted in downtime scattered throughout a three-week period of scheduled operations, impacting many more user experiments than the extension of the May shutdown (see table).

While a few large events can dominate the reliability statistics for any given year, the impact of small-duration but more frequent failures can be devastating for a single user's experimental run. Recognizing this problem, the NSLS has, for many years, run a preventive maintenance program to minimize equipment failures. Downtime faults and system failures that do occur are carefully monitored to look for trends and address problems where possible. The observed trends can result in significant investment by the NSLS in machine improvement efforts.

Both the Accelerator Division and the Operations and Engineering Division devoted a great deal of effort to NSLS machine improvements this year. Digital closed-orbit feedback has now been implemented in both planes on the x-ray ring, the culmination of several years work on orbit stabilization. New machine improvement activities have also been initiated. The injection system, including the linac, booster, and transport lines to the rings, has been the subject of an active study to characterize and improve the system's performance and reliability. Diagnos-





(A) Upstream before replacement: This photograph shows the injection point into the x-ray ring. It is a heavily shielded area because there can be significant losses on injection. The failing injection septum chamber is buried within this part of the ring. Replacing it required removing all of the shielding visible in the photograph, parting two large quadrupole magnets, removing the kicker magnet and supply, and removing the trims and all of the diagnostics attached to the injection septum. An activity of this magnitude would normally be reserved for a winter shutdown. (B) Upstream during replacement: This photo was taken during the installation process on May 11. The extent of the disruption of the machine is quite obvious. To protect against inadvertent damage as the machine components were reinstalled, the ceramic chamber was covered in bubblewrap. (C) Replacement Chamber: The spare Injection Septum Chamber is shown during preparations for the installation. The small port in the foreground is where the injected beam enters the machine. The ceramic chamber has a copper sleeve inside of it that surrounds the circulating beam to shield it from the field of the pulsed magnet that steers the injected beam into the ring. The replacement chamber dimensions were checked against the pulsed magnet (BXISH) and the ring girder to assure smooth installation. The entire assembly was prebaked before installation, which was a significant factor in the fast commissioning of the machine.

tics are being added to the transport lines and booster ring to monitor and improve the injection efficiency into the storage rings.

High-level accelerator modeling software developed over the last five years at the Advanced Light Source and SPEAR was successfully ported to the NSLS for use in machine studies of the storage rings. These MATLAB-based tools are linked to the NSLS control system and were used to restore the eight-fold symmetry of the x-ray ring lattice. Trim supplies on the 'D' family of quadrupoles are required to implement the lattice corrections. Significant effort was invested by the Electrical Systems Section to make sure the QD-trim supplies would be sufficiently robust to provide the required corrections and operate reliably. More about the lattice symmetrization work can be found in the Accelerator Division article in this report.

Group Area/System	Number of Faults			Downtime [hr]	
	Total	X- DT	U- DT	X-ray	UV
Total Charges to Down Time					
Controls and Diagnostics	103	38	14	29.3	9.5
Power Systems	218	109	15	106.9	22.0
Utilities	77	42	20	258.9	24.5
Miscellaneous	69	37	9	37.1	1.2
	467	226	58	432.2	57.2
Major Events					
Water Leak damaged Ion Pump feedthrough				24.0	
Persistent XRF1 Faults				17.3	
XRF1 Tube and Socket Replacement				13.4	
XQD trim failure				20.2	
BXESH1 failures				17.6	
BXISH Chamber Replacement				192.0	
				284.5	0.0
Balance to 'Routine' Faults					
				147.6	57.2

The winter 2004 shutdown schedule was originally planned with the goal of completing the radio frequency (RF) cavity upgrades on the x-ray ring. Unfortunately, we entered the fiscal year with a very austere budget under a continuing resolution. Although the new cavity is ready for installation, we deferred the task to mitigate the risk of damage to the machine that could draw on contingency funds. The shutdown was instead dedicated to routine maintenance and compelling installation tasks. One such task was the replacement of another injection ceramic for the BXIFB1 bump on the x-ray ring, which had begun to leak over the summer. Since this work required venting superperiod 8, the water-cooled 'speedbump' downstream of X1 was also removed. The water-cooling had been removed some time ago due to a leak, and with the advent of the active interlock system it was no longer required.

A number of activities to support initiatives from other divisions were also undertaken during the year. A major upgrade of the X25 wiggler to a one-meter-long minigap undulator (MGU) was initiated. The program's justification and coordination are provided by the User Science Division, the magnetic design is being undertaken by the Accelerator Division, and the mechanical and electrical design for the MGU, its controls, and the vacuum system is being performed by the Operations and Engineering Division. A bit further out, but following a similar path, is the development of a new insertion device program at beamline X9. Engineering design and analysis are also being provided to support several end station development projects, and significant support was provided for the energy upgrade of the Deep Ultra-Violet Free Electron Laser (DUV-FEL). The details of these activities can be found in the Accelerator Division article in this report.

Although not directly visible to the user community, substantial investment was made this year in safety programs. This included design reviews for new systems, documenting existing equipment, and developing procedures for maintenance and troubleshooting that address the heightened safety expectations of the Department of Energy. These activities are really investments for the future that keep our staff and users safe and, in the long run, will pay dividends in continued robust operations of the NSLS.

In fact, the vast majority of what the OED does is transparent to our user community, something we diligently strive to achieve. Through the hard work and dedication of the staff, most of the operational issues are headed off before they become problems. When problems do arise, we make every effort to minimize their impact on our users' research. In this way, we continue to work with the other NSLS divisions to ensure that our user community continues to be one of the most productive.